REMARKS

Claims 1-26 were pending in the application. Claims 13 and 17 are canceled. Claims 1, 11 and 14-16 are amended. Claims 27-31 are added. Claims 1-12, 14-16, and 18-31 are now pending in the application. Claims 1 and 11 are the independent claims. Reconsideration of the amended application is respectfully requested.

The Examiner rejected claims 1-5 under 35 USC §102 as being anticipated by Liu et al. In particular, the Examiner stated that Liu et al. disclose an NMR imaging process and apparatus where an imaging object is subjected to a uniform magnetic field (Fig. 1A, item 14), and orthogonal magnetic field gradients (Fig. 1A, item 20; column 4, lines 9-13). The Examiner further stated that Liu et al. apply RF energy to the imaging object according to a fast-spin echo technique ("RF", as shown in Figs. 2 and 7), and subsequently apply RF energy to the imaging object according to a driven equilibrium technique (Fig. 6; column 8, lines 9-19).

Independent claim 1 recites an NMR imaging process. The process includes subjecting the imaging object to a uniform polarizing magnetic field, applying orthogonal magnetic field gradients to the imaging object, applying RF energy to the imaging object according to a fast-spin echo technique, and subsequently applying RF energy to the imaging object according to a driven equilibrium technique.

In contrast, Liu et al. describe a magnetic resonance scan calibration and reconstruction technique for multi-shot, multi-echo imaging. Liu et al. describe a procedure in which a phase map for each echo is created by a low resolution two-dimensional Fourier transform image of k-space views collected close to the zero

amplitude PE stepping gradient and using the phase map to correct the final image data during two-dimensional Fourier transform reconstruction of the image. See column 2, line 49 through column 3, line 9, and column 5, line 40 through column 6, line 41. Liu et al. show a number of imaging sequences. However, Liu et al. do not disclose applying RF energy to the imaging object according to a driven equilibrium technique, after applying RF energy to the imaging object according to a fast-spin echo technique, as recited in claim 1.

In describing Fig. 6, at column 8, lines 9-19, Liu et al. state that "other" driven equilibrium sequences "are also contemplated." However, no driven equilibrium techniques are described, nor is there any suggestion as to how such a technique would be applied. For example, Fig. 6 shows neither the RF pulses nor the gradient pulses necessary for a driven equilibrium sequence, and the cited passage describing Fig. 6, at column 8, lines 9-19, does not describe applying RF energy to the imaging object according to a driven equilibrium technique.

In typical driven equilibrium techniques utilized with spin echo sequences, spins in the X-Y plane are driven back to alignment with the Z-axis in order to shorten the time period required for the spins to return to equilibrium. As a result, the data acquisition time is shortened, and image contrasts can be manipulated in pulse sequences at a high repetition rate. Such a technique is not shown in the drawing figure cited by the Examiner, and the description of such a technique is not included in the cited passage. Thus, although the term "driven equilibrium" is used, the technique is not described, nor is it disclosed or suggested how such a technique could be applied to the disclosed process.

For at least the foregoing reasons, Liu et al. cannot anticipate the invention recited in claim 1. Claims 2-5 depend from claim 1, and therefore also cannot be anticipated by Liu et al., because the distinguishing features noted above, as well as due to the additional distinguishing features recited by these dependent claims. The rejection of claims 1-5, therefore, should be withdrawn.

The Examiner rejected claims 11-18 and 24 under 35 USC §102 as being anticipated by Zur. It should be noted that Zur Figs. 2a, 2b, and 2c show a calibration optimization sequence. Fig. 3 shows a full imaging sequence applied with an object under test. In citing portions of the reference that ostensibly disclose elements recited in the claims, the Examiner refers to Figs. 2a, 2b, and 2c, and Fig. 3, and the corresponding respective descriptive passages interchangeably. However, it is respectfully submitted that only Fig. 3, the imaging sequence, and the description thereof, is applicable to the instant claims. Independent claim 11 includes elements such as subjecting an imaging object to a polarizing magnetic field, which is not performed during the calibration sequence. Further, claim 11 recites applying a first 90-degree RF pulse, followed by a sequence of 180-degree pulses, followed by a second 90-degree RF pulse. These are not a part of the calibration process shown in Figs. 2a, 2b, and 2c, and therefore none of the features of the claims should be sought there. Rather, valid rejections of the claims should only reference Fig. 3 for process elements, and Fig. 4 for the environment in which the process is conducted, and the related descriptions thereof.

As amended, independent claim 11 recites an NMR imaging process. The process includes subjecting the imaging object to a uniform polarizing magnetic field, applying orthogonal magnetic field gradients to the imaging object, applying a first 90-degree RF

excitation pulse, applying a sequence of 180-degree RF excitation pulses following the first 90-degree RF excitation pulse, and applying a second 90-degree RF excitation pulse following the sequence of 180-degree RF excitation pulses. Each of the 180-degree RF excitation pulses in the sequence generates a spin echo, and at least one spin echo is encoded differently than another spin echo. The last two features are incorporated directly from claims 13 and 17, which are canceled.

Thus, as amended, claim 11 incorporates the elements of original claim 11, as well as those of claims 13 and 17. Regarding claim 11, the Examiner stated that Zur teaches an NMR imaging process and system, where an imaging object is subjected to a uniform polarizing magnetic field (Fig. 4, items 82-84), and orthogonal magnetic field gradients (Fig. 4, items 85-88). The Examiner further stated that Zur applies a 90-degree RF excitation pulse (Fig. 3, item 51), followed by a sequence of 180-degree RF excitation pulses (Fig. 3, items 54 and 62, which is followed by a second 90-degree excitation pulse (Fig. 3, item 54; column 5, line 62 through column 6, line 9). Regarding claim 13, the Examiner stated that Zur teaches generation of spin echo by each of the 180 degree RF excitation pulses in the sequence, citing Fig. 1, items 14, 17, 21, and 23. Regarding claim 17, the Examiner stated that Zur teaches different encoding for each spin echo, or that at least one spin echo is encoded differently than another spin echo, citing Figs. 1-3, and the description at column 5, lines 24-30.

It is acknowledged that the imaging sequence shown in Fig. 3 discloses application of a first 90-degree RF pulse, followed by a sequence of two 180-degree RF pulses, followed by a second 90-degree RF pulse. Split and distributed opposite-going Gy pulses 58a and 58b are applied around the first 180-degree RF pulse 54, and similar

Gy pulses 68a and 68b are applied around the second 180-degree RF pulse 62. It is not disclosed that at least one spin echo is encoded differently than another spin echo, as recited in claim 11. The passage cited by the Examiner is not applicable to the claimed invention because it describes the calibration process shown in Fig. 2b, but regardless the spin echo coding is the same for both echo-producing pulses in that case as well.

For at least the reasons stated above, Zur cannot anticipate the invention recite din claim 11. The rejection of claim 11, therefore, should be withdrawn. Claims 12-18 and 24 depend from claim 11, and therefore also cannot be anticipated by Zur, both for the same reasons noted above, as well as because of the additional features they recite. The rejection of claims 12-18 and 24, therefore, should be withdrawn.

The Examiner rejected claims 6-10 and 19-22 under 35 USC §103 as being unpatentable over Liu et al., in view of Zur. The Examiner stated that Zur teaches a 90-degree RF pulse at the center of a plurality of echoes, which has a phase to force magnetization of the imaging object in the direction of the uniform polarizing magnetic field (Figure 3, item 54). The Examiner asserted that it would have been obvious for one of ordinary skill in the art to use a driven equilibrium technique to improve signal to noise ratio.

As noted above in discussing the rejection of claim 1, Liu et al. do not disclose applying RF energy to the imaging object according to a driven equilibrium technique, after applying RF energy to the imaging object according to a fast-spin echo technique. This deficiency is not overcome by the teachings of Zur, and therefore, no combination of the teachings of these references could render obvious the invention recited in claim 1, from which these rejected claims depend. Further, the particular features of these

dependent claims are not suggested by any combination of the teachings of these references.

For example, claim 6 recites applying a 90-degree RF pulse at the center of any of the plurality of different echoes of a multi-echo NMR imaging sequence according to the process of claim 1. It is acknowledged that Zur discloses applying a 90-degree RF pulse at the center of a particular echo of a multi-echo NMR imaging sequence, but it is submitted that Zur does not disclose applying a 90-degree RF pulse at the center of <u>any</u> of the echoes, as recited in claim 6. Further, there is no suggestion in either reference as to why applying a 90-degree RF pulse such as that taught by Zur at the center of any of the echoes of the Liu et al. sequence would provide any advantage. The Examiner asserted that it would have been obvious for one of ordinary skill in the art to use a driven equilibrium technique to improve signal to noise ratio. However, it is respectfully submitted that neither reference teaches or suggests this or any other motivation for the combination.

As a further example, claim 19 recites that the imaging object of claim 1 is a human being who stands upright within the polarizing magnetic field. The Examiner asserted that it would have been obvious to one of skill in the art to have a person stand while being imaged, to improve the subject's comfort level. However, neither reference cited by the Examiner shows a human subject who is standing while being imaged. Both references show only supine subjects (Liu et al. Fig. 1A, Zur Fig. 4). Further, it is submitted that neither reference discloses an NMR scanner in which it is possible for a person to stand, or even suggests a scanner that is adaptable such that a person would be able to stand while being imaged.

As another example, claims 20-22 disclose selecting planes of the imaging object by application of an RF pulse corresponding to a particular angular precession frequency (claim 20), and then selecting additional planes by moving the imaging object (claim 21) or by changing the precession frequency without moving the imaging object (claim 22). The Examiner cited Liu et al. Fig 7, item 52" as disclosing the feature recited in claim 20, without further explanation. However, it is not clear from Fig. 7 that this is disclosed, and the description of Fig. 7 at column 8, lines 20-29 does not disclose that this is what is shown. The Examiner also asserted that the features recited in claims 21 and 22 were commonly used, and that one of ordinary skill in the art would have used them for imaging to improve quality. However, neither reference discloses these features, the Examiner provided no basis for this assertion, and it is not clear how these features improve imaging quality or how they would be applied to the teachings of the cited references.

For at least the foregoing reasons, it is respectfully submitted that no combination of the teachings of the cited references could render obvious the invention recited in claim 1, and therefore of claims 6-10 and 19-22, which depend from claim 1. Further, no motivation for such combination is provided or even suggested in either of the cited references. Further, the cited references do not disclose certain features of claims 6-10 and 19-22, as noted above. The rejections of claims 6-10 and 19-22, therefore, should be withdrawn.

The Examiner rejected claims 23, 25, and 26 under 35 USC §103 as being unpatentable over Zur. As noted above, Zur does not disclose the invention recited in claim 11, from which claims 23, 25, and 26 depend. Regarding claim 23, the Examiner

stated that Zur teaches a human being as the imaging object (Figure 4, item 83). The Examiner asserted that it would have been obvious for one of ordinary skill in the art to use an NMR imaging machine where the human being to be imaged can stand in the uniform magnetic field to improve the comfort level of the person being imaged. The Examiner noted that such machines have been in recent use. However, neither reference cited by the Examiner shows a human subject who is standing while being imaged. Both references show only supine subjects (Liu et al. Fig. 1A, Zur Fig. 4). Further, it is submitted that neither reference discloses an NMR scanner in which it is possible for a person to stand, or even suggests a scanner that is adaptable such that a person would be able to stand while being imaged.

Claims 25 and 26 recite selecting planes of the imaging object by application of an RF pulse corresponding to a particular angular precession frequency, and then selecting additional planes by moving the imaging object (claim 25) or by changing the precession frequency without moving the imaging object (claim 26). The Examiner asserted that these features were commonly used, and that one of ordinary skill in the art would have used them for imaging to improve quality. However, neither reference discloses these features, the Examiner provided no basis for this assertion, and it is not clear how these features improve imaging quality or how they would be applied to the teachings of the cited references.

For at least the foregoing reasons, it is respectfully submitted that the teachings of Zur cannot render obvious the invention recited in claim 11, and therefore of claims 23, 25, and 26, which depend from claim 11. Further, Zur does not disclose or suggest

certain features of claims 23, 25, and 26, as noted above. The rejections of claims 23, 25, and 26, therefore, should be withdrawn.

New claims 27-31 are added. Support for these claims can be found in the specification, for example, in the paragraph beginning on page 13 at line 17. It is respectfully submitted that the features recited in these new claims are not disclosed in the cited references, taken alone or in combination. A check is enclosed in payment of the fee for the excess claims, and for the extension of time. If the check is missing, or made out for an insufficient amount, please charge any deficiency to our deposit account, No. 501998, and notify us accordingly.

It is respectfully submitted that all rejections have been overcome. It is therefore requested that the Amendment be entered, the claims allowed, and the case passed to issue.

Respectfully submitted,

May 15, 2002
Date

Thomas M. Champagne
Registration No. 36,478
IP STRATEGIES, P.C.
806 7th Street, NW
Suite 301
Washington, DC 20001
(202) 289-2700
(202) 289-3594 fax

TMC:lep

Certification under 37 CFR 1.8

May 15, 2002
Date of Deposit

I hereby certify that this Amendment is being deposited with the United States Postal Service as First Class Mail under 37 CFR §1.8 on the date indicated above and is addressed to the Commissioner for Patents, Washington, D.C. 20231.

Thomas M. Champagne	
Typed or printed name of person mailing Amendment	Signature of person mailing Amendment

VERSION WITH MARKINGS TO SHOW CHANGES MADE

1. (Amended) An NMR imaging process, comprising:

subjecting the imaging object to a uniform polarizing magnetic field;

applying [orthogonal] magnetic field gradients to the imaging object;

applying RF energy to the imaging object according to a fast-spin echo technique; and

subsequently applying RF energy to the imaging object according to a driven equilibrium technique.

2. (Unchanged) The process of claim 1, further comprising:

detecting a nuclear magnetic resonance signal emitted by the imaging object; and

processing the nuclear magnetic resonance signal to provide imaging data.

3. (Unchanged) The process of claim 1, wherein the fast-spin echo technique includes application of a multi-echo NMR imaging sequence.

4. (Unchanged) The process of claim 3, wherein the multi-echo NMR imaging sequence includes a plurality of different echoes, and wherein each of the plurality of different echoes is encoded differently.

5. (Unchanged) The process of claim 3, wherein the multi-echo NMR imaging sequence includes a plurality of different echoes, and wherein at least one of the plurality

of different echoes is encoded differently than another one of the plurality of different echoes.

6. (Unchanged) The process of claim 3, further comprising applying a 90-degree RF pulse at the center of any of the plurality of different echoes.

7. (Unchanged) The process of claim 6, wherein the applied 90-degree RF pulse has a phase such that magnetization of the imaging object is forced in the direction of the uniform polarizing magnetic field.

8. (Unchanged) The process of claim 3, wherein the multi-echo NMR imaging sequence includes a first 90-degree RF pulse followed by a series of 180-degree RF pulses.

9. (Unchanged) The process of claim 8, wherein the series of 180-degree RF pulses includes *n* 180-degree pulses, which are followed by *n* echoes.

10. (Unchanged) The process of claim 9, further comprising applying a second 90-degree RF pulse at a center of the *nth* echo, such that magnetization of the imaging object is oriented in the direction of the uniform polarizing magnetic field.

11. (Amended) An NMR imaging process, comprising:

subjecting the imaging object to a uniform polarizing magnetic field;

applying [orthogonal] magnetic field gradients to the imaging object;

applying a first 90-degree RF excitation pulse;

applying a sequence of 180-degree RF excitation pulses following the first 90-degree RF excitation pulse; and

applying a second 90-degree RF excitation pulse following the sequence of 180-degree RF excitation pulses;

wherein each said 180-degree RF excitation pulse in the sequence generates a spin echo; and

wherein at least one said spin echo is encoded differently than another said spin echo.

12. (Unchanged) The process of claim 11, further comprising:

detecting a nuclear magnetic resonance signal emitted by the imaging object; and

processing the nuclear magnetic resonance signal to provide imaging data.

13. (Canceled)

14. (Amended) The process of claim [13] 11, wherein each said spin echo precedes a next 180-degree RF excitation pulse in the sequence.

15. (Amended) The process of claim [13] 11, wherein the second 90-degree RF excitation pulse is applied at a center of the spin echo generated by a last 180-degree RF excitation pulse in the sequence.

16. (Amended) The process of claim [13] <u>11</u>, wherein each said spin echo is encoded differently.

17. (Canceled)

18. (Unchanged) The process of claim 11, wherein the second 90-degree RF excitation pulse has a phase such that magnetization of the imaging object is forced in the direction of the uniform polarizing magnetic field.

19. (Unchanged) The process of claim 1, wherein the imaging object is a human being, and the uniform polarizing magnetic field is produced by a magnetic resonance imaging system, wherein the human being stands upright within the uniform polarizing magnetic field.

20. (Unchanged) The process of claim 2, wherein applying RF energy to the imaging object according to a fast-spin echo technique includes applying an RF pulse corresponding to the angular precession frequency for a selected plane of the imaging object.

21. (Unchanged) The process of claim 20, further comprising, after providing the imaging data, moving the imaging object and applying an RF pulse corresponding to the same angular precession frequency, to select a different plane of the imaging object.

22. (Unchanged) The process of claim 20, further comprising, after providing the imaging data, applying an RF pulse corresponding to a different angular precession frequency, to select a respective different plane of the imaging object, without moving the imaging object.

23. (Unchanged) The process of claim 11, wherein the imaging object is a human being, and the uniform polarizing magnetic field is produced by a magnetic resonance imaging system, wherein the human being stands upright within the uniform polarizing magnetic field.

24. (Unchanged) The process of claim 12, wherein the first 90-degree RF excitation pulse corresponds to the angular precession frequency for a selected plane of the imaging object.

25. (Unchanged) The process of claim 24, further comprising, after providing the imaging data, moving the imaging object and applying the first 90-degree RF excitation pulse corresponding to the same angular precession frequency, to select a different plane of the imaging object.

26. (Unchanged) The process of claim 24, further comprising, after providing the imaging data, applying the first 90-degree RF excitation pulse corresponding to a

different angular precession frequency, to select a respective different plane of the imaging object, without moving the imaging object.

27. (New) The process of claim 16, wherein

each said spin echo is encoded by one or more of the magnetic field gradients; and

the magnetic field gradient that encodes the spin echoes is stepped in amplitude to encode each said spin echo differently.

28. (New) The process of claim 27, wherein the magnetic field gradient that encodes the spin echoes is stepped in amplitude to generate data from each said spin echo to fill respective different lines in k_x, k_y- space.

29. (New) The process of claim 28, wherein all the data generated from the spin echoes fills the entire k_x, k_y- space so that an image of the imaging object can be constructed from the data.

30. (New) The process of claim 29, wherein the k_x, k_y- space has dimensions of 2^n x 2^n data points, and there are 2n 180-degree RF excitation pulses in the sequence.

31. (New) The process of claim 28, wherein the different lines in k_x, k_y- space are consecutive lines in k_x, k_y-space.